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RECOVERY AND UTILIZATION OF PULP FROM WHITE POTATO STARCH FACTORIES

By Roderick K. Eskew,[1] Paul W. Edwards[2]
and Clifford S. Redfield[3]

INTRODUCTION

A pilot plant for the study of white potato starch manufacture and the recovery and utilization of wastes from these operations is now under construction at the Eastern Regional Research Laboratory. Delivery on equipment is slow, however, and it will be many months before significant data can result from our studies. Because the problem of waste disposal has become acute in the Maine potato starch producing areas, it appears desirable to make known at once such information as is available, even though it is fragmentary and does not represent final conclusions resulting from an integrated research program.

The cost estimates given here, since they are not based on experiments designed to yield reliable cost data, do not necessarily represent the actual cost of large-scale operations. They are given merely to indicate the order of magnitude of the costs and to show that the recovery and utilization of white potato pulp may be profitable as well as helpful in solving the problem of contamination of streams.

Recovery Process

BACKGROUND: A survey made during the summer of 1947 of European practices for the industrial utilization of potatoes revealed that, except in small factories, the pulp from potato starch manufacture is almost invariably pressed and dried for feed. This is done even where no attempt is made to save the more difficultly recoverable proteins in plant effluents. Where the pulp is not dried, the wet pulp is accumulated and used locally by farmers for hog feed. In Idaho at least one potato starch plant is partially dewatering its waste pulp and selling it locally for dairy feed.

The pulp, with or without liming, is dewatered in roller presses, usually of the Büttner type. The pulp is dried in a variety of driers. Büttner scraper-type driers identical with those used for drying the starch have been successful -- also direct-heat, parallel-flow, high-temperature driers and blast-type flash driers.

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In 1943 under this Bureau's direction more than 2 million pounds of white potatoes were processed for starch at Laurel, Mississippi, in a plant customarily used for sweetpotato starch production.[4] The white potatoes used for this work were immature. Their moisture contents ranged from 78 to 82 percent and they were low in starch 9 to 11 percent. The pulp was limed and passed through a dewatering reel and then two roller presses, which reduced the moisture content to about 73 percent. In other work at Laurel, double-pressed pulp from potatoes harvested throughout the season had an average moisture content of 70 percent

The dewatered pulp was then dried in a rotary, steam-tube drier. No difficulties were encountered in these operations, and the product is reported to have been "of good granular consistency, light in color and of agreeable odor." A typical sample analyzed as follows:

	Percent
Crude protein	4.81
Crude fat	0.20
Crude fiber	7.97
Nitrogen-free extract	72.67

Apparently it is entirely feasible to recover white potato pulp by a comparatively simple process and with standard equipment.

PROPOSED PROCESS: From earlier Bureau investigations, from observation of European practices, from a study of Maine potato starch plants, and from experiments at this Laboratory on liming, dewatering and drying white potatoes, experience has been gained which suggests that the following pulp recovery procedure could be adapted for use in the white potato starch manufacturing areas of this country. Figure 1 shows the process diagrammatically.

The pulp leaving the starch removal screens would be discharged into a tank and mixed with lime. The limed pulp would be partly dewatered on a vibrating screen and after further dewatering by pressing would be dried in a steam-tube rotary drier. The equipment called for here is that required to handle the pulp from a factory producing 10 tons of white potato starch per 24-hour day. Such a factory should produce about 2 tons of pulp at 10 percent moisture.

Tests made in Maine starch plants show that the pulp leaving the starch-removing screens is about 96 percent water and 4 percent solids. This pulp contains pectin and other constituents which make it difficult to dewater by screening and pressing. Lime is therefore added to facilitate the dewatering of the pulp. The exact amount of lime required for good pressing will have to be determined by tests. It is believed that an amount equal to that required to saturate the water associated with the pulp will be proper. The quantity of lime will not be objectionable when the pulp is used for feed. Liming can be done effectively in a wooden

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[4] Unpublished reports of Sweetpotato Products Division, Southern Regional Research Laboratory.

RECOVERY OF WASTE PULP FROM WHITE POTATO STARCH FACTORIES

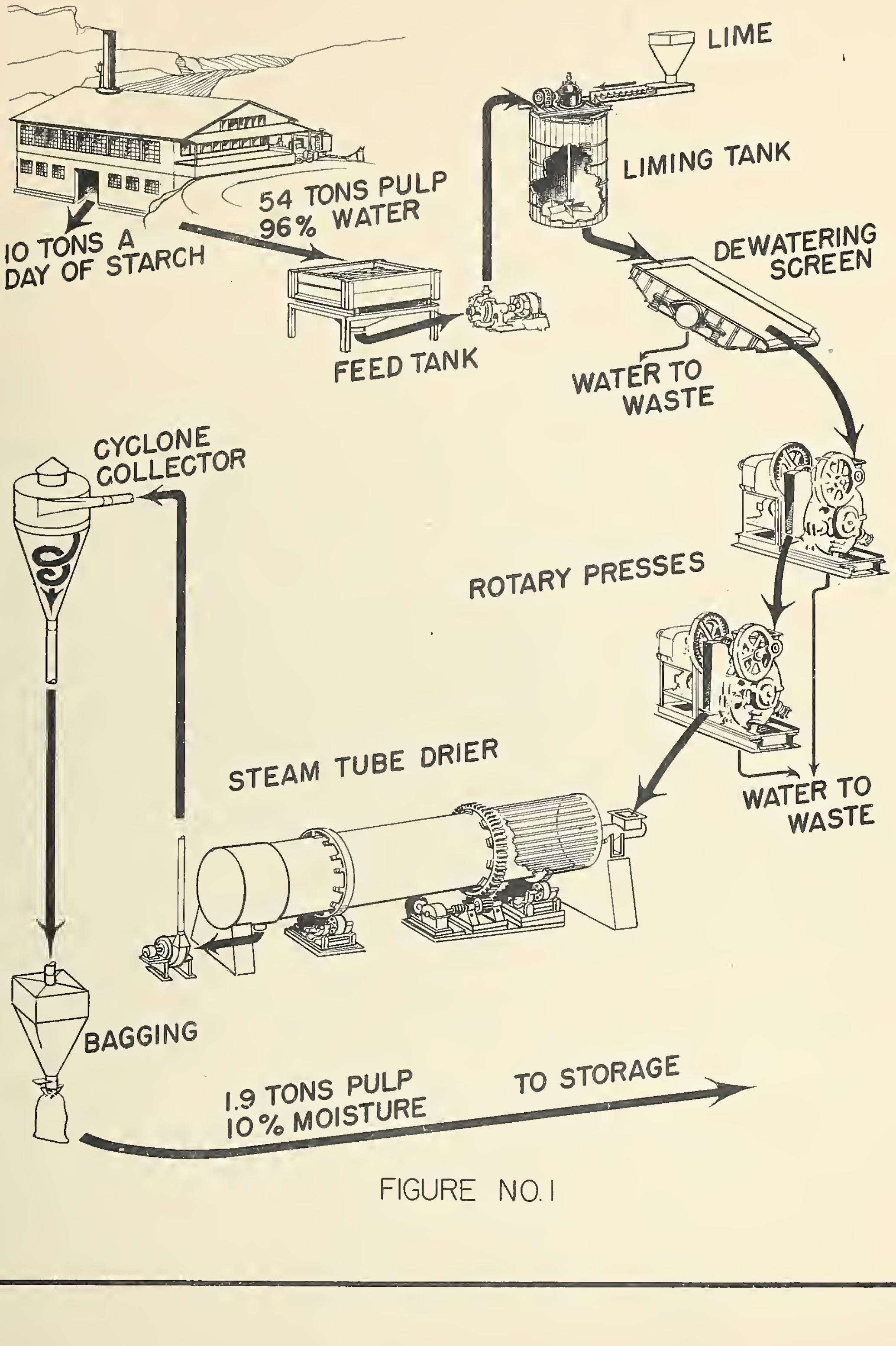

FIGURE NO. 1

tank equipped with an agitator The hydrated lime can be fed automatically at a rate commensurate with the rate of the pulp entering the tank. If the tank has a capacity of 1,000 gallons, the average time of retention will be about half an hour. Thus, it will also serve as a reservoir to equalize discrepancies in operating rates in the starch factory and in the pulp-recovery system.

Limed pulp containing 96 percent water cannot be satisfactorily handled in a press of the type it is proposed to use. Therefore, some dewatering should first be done on a shaker screen. This can be of the same general construction used in the starch-screening operations. It should be about 4 feet wide and 10 feet long and should be about 90 mesh. This should reduce the water content to between 92 and 93 percent.

Because of the high moisture content, effective dewatering cannot be accomplished in one pressing; therefore, two presses must be used in series, or arrangements made to use the same press for the two successive operations. The press recommended is a continuous rotary type. Since in many starch plants potato grinding and screening are done only on an 8 hour day basis, the plan suggested here is to use two presses in series, processing the entire pulp output of the plant as fast as it develops, that is, in 8 hours. This entails using two small commercial-size presses. If, however, in a factory with a capacity of 10 tons of starch per day, grinding is done over a 22-hour period, pulp will be produced too slowly for two small presses to handle efficiently. Therefore, tank capacity of about 9,000 gallons would have to be provided for storing the pulp produced during a 14-hour period. The pulp would then be processed only on the day shift.

No data are available on the loss in solids in the expressed juice. Since this is approximately 20 percent in whole ground potatoes, it probably would be less in pulp, since the pulp is much lower in soluble solids. However, in calculating the costs we have assumed the loss to be 20 percent. It was also assumed that two pressings would reduce the moisture content to 70 percent.

The pressed pulp can be fed to a small, rotary steam tube drier, which should have about 680 square feet of tube drying surface. It should be about 4 feet in diameter and 30 feet long and should dry the pulp from a 10-ton starch factory in about 8 hours. Judging by experience,[4] the product should be of good granular consistency, with a light color and agreeable odor.

A small, direct-heat, rotary drier should also prove satisfactory for drying the pressed pulp. A single-pass unit of this type operating at 60 percent over-all efficiency and having a drying chamber about 4 feet in diameter and 30 feet long should dry the pressed pulp from a 10-ton starch factory in about 8 hours. In the absence of experimental data, the assumption is made that the drying characteristics of the pressed pulp are about the same as those of pressed potatoes. Actually the pulp may dry more readily than the potatoes. Although drying potato pulp in a direct-heat drier would probably not constitute so great a hazard as drying the ground potatoes themselves, nevertheless the dried pulp contains more than 40 percent starch on a moisture-free basis, and hence direct-heat drying is not entirely free of explosion hazard. Therefore, it would be undesirable to locate the drier immediately adjacent to other buildings.

The estimated cost of a steam tube drier for this plant is about $6800 Where it is necessary to install a boiler to supply steam, the cost of the steam-tube drier, boiler and boiler housing would be about $9550. A small, direct-heat, single pass, rotary drier for the same plant would cost about $7500.

The calculated capital cost for a plant where steam is available without expanding boiler-house facilities is shown in table 2 to be $26,057. If an additional boiler is required, the capital cost would be $28,807. Where a direct-heat drier is used, the cost is $27,316. Thus, where boiler capacity is available, the capital cost for the plant using a steam-tube drier is about $1300 less than a plant which uses a direct-heat drier. Where sufficient boiler capacity is not available, the direct-heat drier installation will cost about $1500 less than the steam-tube drier plant.

Feed Value of Product

Sufficient quantities of dried waste from white potato starch factories have not been available for large-scale feeding tests, in which its feed value could be evaluated. Some informal feeding trials indicate that the dried pulp is readily eaten by cows.

In order to indicate the probable value of dried potato pulp, prices for feed stuffs of similar composition are given in table 1.

Table I

Composition and Price of Various Pulp Feeds

	Crude protein, %	Crude fat, %	Crude fiber, %	Nitrogen-free extract, %	Selling price, $ per ton (f.o.b. point of origin)
Dried potato pulp[1]	4.81	0.20	7.97	72.67	45.0 (assumed value)
Dried citrus pulp[2]	5.50	2.50	10.50	62.00	45.0
Dried beet pulp[3]	9.00	0.80	18.80	59.90	60.0

[1] *Unpublished reports of Sweetpotato Products Division, Southern Regional Research Laboratory.*

[2] *Analysis "Texsun" dried citrus pulp, "Industrial and Engineering Chemistry," 40, 377, 1948. Selling price f.o.b. Rio Grande Valley shipping points, "Feedstuffs," 20, 79, March 6, 1948.*

[3] *Analysis dried beet pulp, "Feeds and Feeding," Morrison, Ed. 20, p. 978. Selling price at Ogdon, Utah, "Feedstuffs," 20, p. 79, March 6, 1948.*

Based on composition alone, dried potato pulp might be expected to command a price of about $45.00 a ton. However, in Maine there is a demand for cattle and poultry feed in excess of the local supply, requiring importation of such materials at high freight rates. Thus, locally produced potato pulp might well command a price above $45.00 a ton.

Conclusions

From the best information available at this time, it can be assumed that the cost of producing dried potato pulp would be about $37.00 to $40.00 per ton, depending on the method of drying employed (table 3). Since the estimated selling price is above these figures, it appears that pulp recovery would be a profitable undertaking. The capital investment necessary to recover the pulp from a plant producing 10 tons of starch per day would range from approximately $26,000 to $31,500, depending on the type of drier used (table 2). The return on the investment can be estimated only when the local selling price is known. Based on a selling price of $45.00 per ton f.o.b. factory, the return on the investment would be about 6 to 12 percent. This includes all costs except selling costs. For emphasis it should be repeated that these figures are based on assumptions and not on experimental data. Should the loss of pulp on pressing exceed 34 percent in the process which uses a steam-tube drier (where steam is available) or 28 percent for the direct-heat process, it might not be a profitable business.

The removal of pulp from the starch plant effluents will lessen the now serious problem of stream contamination.

Cost Calculations

Cost estimates are based on the assumption that the pulp-recovery plant will operate 200 days each year. They are also based on the following four assumed operating conditions:

Case I. The starch factory has sufficient boiler capacity to operate the steam-tube drier and that space is available to house all equipment except the drier.

Case II. A boiler must be supplied to furnish steam for the steam-tube drier and that space is available to house all equipment except the boiler and drier.

Case III. Sufficient boiler capacity is available to operate the steam-tube drier and that a building must be erected to house all equipment.

Case IV. The starch factory has space available to house all equipment except the direct-heat drier.

Data for these four cases are given in summarized form in table 3. The detailed calculations on file at the Eastern Regional Research Laboratory are too voluminous to be included here.

Table 2

CAPITAL COSTS

	CASE I	CASE II	CASE III	CASE IV
Building: for housing the drier	1,920.00	1,920.00		2,304.00
Building: for housing all equipment including drier			7,395.00	
Equipment:				
Centrifugal pump, motor, starter, and switch	268.00	268.00	268.00	268.00
Wood tank, 1,000 gallons	279.76	279.76	279.76	279.76
Agitator, turbine type, 5 H. P. motor and starter	727.90	727.90	727.90	727.90
Limefeeder	371.25	371.25	371.25	371.25
Vibrating screen 4 x 10 feet; 5-H. P. motor, starter, and switch	1,753.32	1,753.32	1,753.32	1,753.32
2-Continuous rotary presses, motor, and starters	7,250.00	7,250.00	7,250.00	7,250.00
Drier, evaporative capacity at least 800 pound per hour.	6,800.00	6,800.00	6,800.00	7,500.00
Blower, 3/4-H. P. motor, starter and switch	197.50	197.50	197.50	197.50
Dust collector (cyclone).	170.00	170.00	170.00	170.00
Bagging bin, 5,000 pound capacity, 5 feet diameter, 6 feet high	540.00	540.00	540.00	540.00
Pipe, valves, and duct work	626.48	626.48	626.48	626.48
Pipe and duct work installation	563.83	563.83	563.83	563.83
Erection of equipment	4,589.43	4,589.43	4,589.43	4,764.43
Boiler and housing		2,750.00		
Total	26,057.47	28,807.47	31,532.47	27,316.47

Table 3

SUMMARY COST SHEETS

	CASE I	CASE II	CASE III	CASE IV
Material	2.57	2.57	2.57	2.57
Labor	16.00	16.00	16.00	16.00
Prime cost	18.57	18.57	18.57	18.57
Factory overhead				
Indirect material				
Bags	3.81	3.81	3.81	3.81
Indirect labor				
Supervision	4.00	4.00	4.00	4.00
Indirect expense				
Insurance	.65	.72	.79	.68
Taxes	2.61	2.88	3.15	2.73
Interest	3.26	3.60	3.94	3.41
Social Security	.20	.20	.20	.20
Workmen's compensation	.25	.25	.25	.25
Unemployment insurance	.60	.60	.60	.60
Depreciation	8.97	10.07	10.34	9.28
Maintenance, repair and renewals	7.81	8.06	9.46	8.14
Power	5.19	5.19	5.19	5.21
Steam	9.26	9.26	9.26	
Oil				14.99
Miscellaneous factory expense	5.00	5.00	5.00	5.00
Total factory overhead	51.61	53.64	55.99	58.30
Factory cost	70.18	72.21	74.56	76.87
Factory cost per ton of product based on production of 3807 pounds daily for 200 days per year.	36.86	37.94	39.16	40.38